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SAMPLING AND ANALYSIS PLAN AMENDMENT
FOR THE
CHEVRON ORLANDO SITE
REMEDIAL INVESTIGATION AND FEASIBILITY STUDY

Prepared for: Chevron Chemical Company

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CHAPTER 1.0

INTRODUCTION

1.1 BACKGROUND

The Chevron Chemical Company site (site) is located in the 3100 block of North Orange Blossom Trail (Highway 441), Orlando, Orange County, Florida. The site is bordered to the east by Orange Blossom Trail, to the west by industrial facilities, to the south by railroad tracks, and to the north by a mobile home park. Lake Fairview is located approximately 1,000 feet northwest of the property. The total area of the site is approximately five acres. A site location map is provided as Figure 1-1.



Chevron Chemical Company (Chevron) owned and operated the site as a chemical blending facility for pesticides and other crop sprays from 1949 to 1976. Chemicals used as carrier solvents in the pesticide formulation include xylene, mineral oil, mineral spirits, and aromatic naphtha. A few of the pesticides formulated in large volumes include chlordane, DDT, BHC-lindane, dieldrin, and aldrin. A rinsate lagoon was used to collect drum rinsate and stormwater.

In 1978, the site was purchased "as is" by Mr. Robert R. Uttal, owner and operator of Central Florida Mack Truck Company. Mr. Uttal dismantled and sold much of the pesticide formulating and storage equipment and disposed of remaining inventory and cleaning residues on-site. The site was utilized as a truck sales and service facility until 1987. Waste oil, solvents, and motor fuels

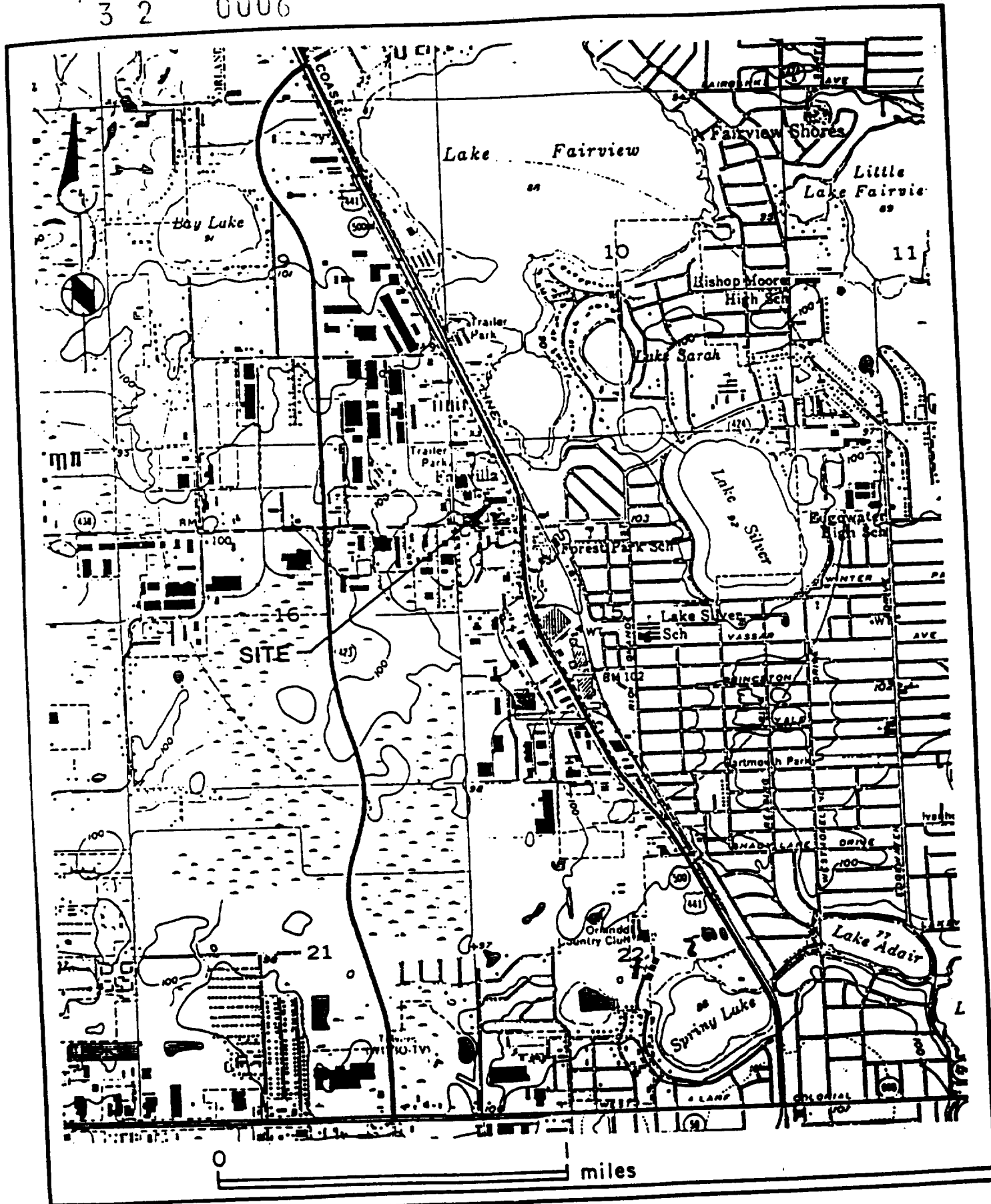


FIGURE 1-1 Site Location Map

were stored and spilled or disposed of on-site. Various truck parts, including used oil filters, were disposed of on-site.

Mr. Uttal is the current property owner. Central Florida Mack Truck Company went out of business in 1987, with Mr. Uttal retaining ownership of the property.

On May 15, 1990 an Administrative Order on Consent, EPA Docket No. 90-37-c, was executed between the U.S. Environmental Protection Agency (EPA), Robert R. Uttal, and Chevron for the performance of a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) removal action at the site. Chevron prepared and submitted the Contamination Assessment Report (Brown and Caldwell, 1990), which described the distribution and characteristics of contaminants in the soil and groundwater at the site. The Removal Action Plan (BCC, 1991), Sampling and Analysis Plan (BCC, 1991), Quality Assurance Project Plan (BCC, 1991), and Site Safety and Health Plan (BCC, 1991) were prepared to summarize the planned removal action activities.

The removal action was initiated in December 1991 and continued through September 1992. The removal action incorporated excavation and disposal of approximately 17,650 tons of non-hazardous pesticide/petroleum contaminated soil, the excavation and disposal of approximately 131 tons of parathion contaminated soil, the excavation and disposal of approximately 4,500 tons of petroleum contaminated soil, and demolition and disposal of all on-site structures. Following excavation and demolition, the site was backfilled with clean native soil, graded, and seeded. The Removal Action Report (BCC, 1992) summarizes the removal action activities, and the results of sampling and analysis conducted during the removal action.

Groundwater samples collected prior to and during the removal action identified the presence of benzene, chlorobenzene, dichlorobenzene, ethylbenzene, xylene, toluene, and BHC isomers in the groundwater beneath and downgradient of the site. Based on the detection of these compounds, and Chevron's desire to proceed with the assessment and remediation of the groundwater, Chevron negotiated an Administrative Order by Consent (AOC) for a Remedial Investigation and Feasibility Study (RI/FS) with the EPA. The RI/FS will be conducted in accordance with the Superfund Accelerated Cleanup Model (SACM) program.

1.2 SAMPLING AND ANALYSIS GOALS

The goals of the sampling and analysis for the RI/FS are to characterize the magnitude and extent of groundwater contamination associated with the site, and to measure attenuation and degradation of contaminants of interest (COIs) in the surficial aquifer for use in modeling solute fate and transport. Specific goals are:

- To characterize the magnitude and extent of contaminant migration in the surficial aquifer.
- To identify the potential for continuing contaminant migration in the surficial aquifer.
- To identify the potential for contaminant migration through the Hawthorn formation (confining unit) into the Floridan aquifer.

- To determine the post-removal action geochemical conditions in the shallow aquifer, particularly with respect to the oxidation potential.
- To measure site-specific aquifer adsorption parameters to determine retardation of COIs in the aquifer relative to groundwater.
- To measure site-specific degradation rates for COIs in the groundwater.
- To determine whether contaminant migration through stormwater runoff has occurred to the extent that the soil quality to the north of the site has been affected.

1.3 PURPOSE AND SCOPE OF THE SAPA

The purpose of this Sampling and Analysis Plan Amendment (SAPA) is to amend the Sampling and Analysis Plan (BCC, 1991) to include the planned RI/FS sampling and analysis activities. The proposed RI/FS sampling and analysis activities are summarized in the AOC Scope of Work, which was approved by the EPA on April 5, 1993. The Sampling and Analysis Plan (SAP, BCC, 1991) is included herein by reference, and describes the data collection and sample analysis procedures used during the removal action sampling. This SAPA summarizes the RI/FS data collection activities, and describes the data collection and analytical procedures which may differ from the procedures described in the SAP (BCC, 1991).

CHAPTER 2.0

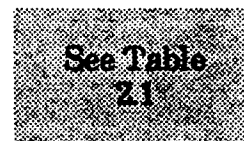
SITE BACKGROUND AND SAMPLING OBJECTIVES

2.1 GENERAL

The site background and environmental setting are described in detail in the Contamination Assessment Report (BCC, 1990) and the Removal Action Report (BCC, 1992), which are included herein by reference.

2.2 DATA QUALITY OBJECTIVES

The data collection procedures are designed to provide the data needed to determine the magnitude and extent of contamination which has migrated from the previous source areas on-site, into the surficial aquifer. The procedures for data collection, bench-scale experiments, and chemical analysis related to determining COI degradation and attenuation in the surficial aquifer are designed to support quantitative modeling of groundwater transport. Model results will then be used to estimate potential exposure-point concentrations for risk assessment, and to evaluate the effectiveness of potential remedial actions. Data quality objectives (DQOs) are identified for specific tasks in Table 2.1.



DQOs will be achieved by following this SAPA. The specific sampling and analytical methods to be employed, and sample locations, are described in Chapters 4 and 5 of this document. The measures that will be taken to check and maintain quality assurance during the sampling and analysis process are described in the Quality Assurance Project Plan Amendment (TASK/PTI, 1993).

**TABLE 2.1. DATA QUALITY OBJECTIVES FOR THE DETERMINATION OF CHEMICAL
ATTENUATION AND BIODEGRADATION PARAMETERS**

Task	Objective	Data Use	Analytical Level	Parameters
Field-measured redox parameters	Determine whether shallow aquifer is oxygenated or anoxic	Calculation of degradation rates	Level I	D.O., Fe(II), S ²⁻ , Eh, pH
Field-measured K _d	Determine magnitude and variability in existing soil/water partitioning (K _d) of COIs in the aquifer	Modeling solute transport, evaluating remedial alternatives	Level III	Chlorinated pesticides, As, Cr, soil TOC
Laboratory-measured K _d	Determine magnitude and variability in potential uptake of COIs from groundwater to soil	Modeling solute transport, evaluating remedial alternatives	Level III	Chlorinated pesticides, As, Cr, soil TOC
Laboratory-measured degradation rates	Determine site-specific biological and abiotic degradation rate of COIs	Modeling solute transport, evaluating remedial alternatives	Level III for EPA Method 8080	Chlorinated pesticides, degradation products

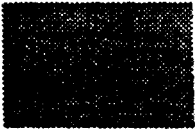
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Additional information regarding site health and safety protocol is provided in the Site Safety and Health Plan (TASK, 1993).

2.2.1 Groundwater Investigation

All field sampling and analysis tasks are directly related to achieving the DQOs. Information from these efforts will be used to characterize groundwater conditions, evaluate contaminant migration potential, evaluate potential risk to human health and the environment, and develop a cost-effective and efficient groundwater remediation plan. Sampling activities will encompass characterization of groundwater plume contaminant concentrations, and characterization of the physical and chemical nature of appropriate migration pathways. A comparison of EPA Maximum Contaminant Levels and Florida Water Quality Criteria, the preliminary applicable and relevant or appropriate requirements (ARARs) for this investigation are presented in Table 2.3 of the SAP (BCC, 1991).

The groundwater investigation will be conducted in two phases. Phase 1 will encompass the sampling of the monitor wells which remain on and adjacent to the site. The samples will be analyzed for purgeable aromatic compounds (EPA Method 602); purgeable halocarbon compounds (EPA Method 601); semi-volatile organic compounds (EPA Method 625); chlorinated pesticides (EPA Method 608); organophosphate pesticides (EPA Method 614); arsenic (EPA Method 206.2); chromium (EPA Method 200.7); and lead (EPA Method 239.2). The locations of the remaining monitor wells are shown on Figure 2-1. The Phase 1 sampling activities will also include collection field-measured redox parameters [i.e., dissolved oxygen, Fe(II), S²⁻, Eh, and pH].



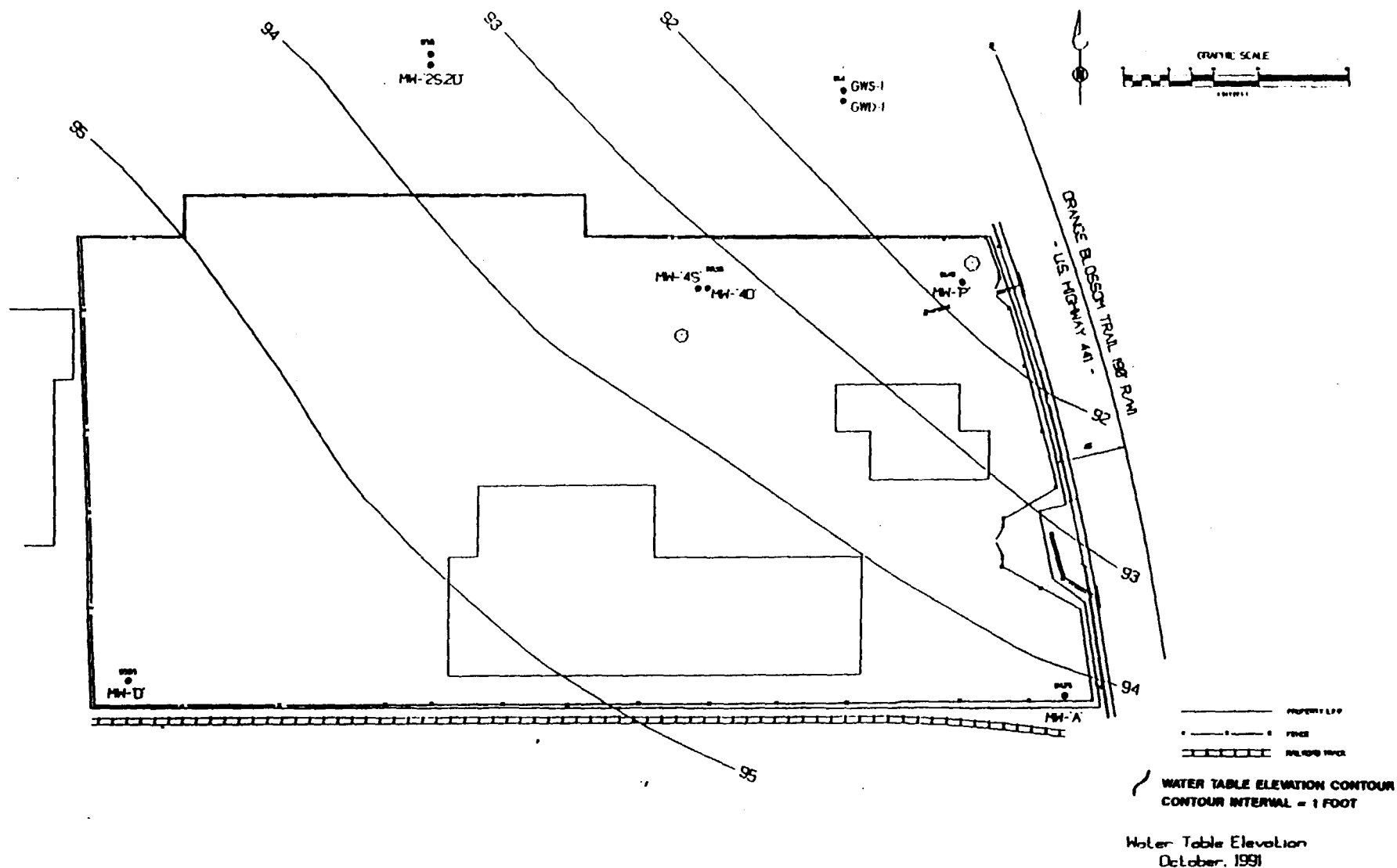


FIGURE 2-1 Existing Wells at the Chevron Orlando Site as of May 1993.

The Phase 1 data will be used, along with literature information and the results of previous investigations, to develop a contaminant fate and transport simulation for the surficial aquifer. The Phase 1 data will also be used to select the contaminants of interest (COIs) for future sampling activities.

The groundwater flow and contaminant fate and transport will be modeled using the USGS 2-dimensional finite element model SUTRA (Voss, 1984). The groundwater flow model domain will extend to the edge of the existing lakes to the north and east of the site. These boundaries will be modeled as constant head boundaries. The south boundary of the model will extend to the nearest surficial aquifer drainage divide (determined from lake water-table elevations) and will be set as a no-flow boundary. The western boundary will also be a no-flow boundary. The no-flow boundaries are at a sufficient distance from the site such that they will not affect the modeled flow field.

Conceptually, the hydraulic gradient in the surficial aquifer is assumed to be driven by the water levels in the lakes and by infiltrating precipitation. Lake water-table elevation data were obtained for the lakes in question from the City of Orlando.

The groundwater flow portion of the model will be calibrated by configuring the boundaries as described above, setting the hydraulic conductivity to the values measured at the site, and varying the regional infiltration rate within the probable range until the hydraulic gradient across the site is approximately matched with historic field measurements. Water levels in the surrounding lakes may also be adjusted within the range of historic water level fluctuations.

Once the hydraulic conditions are calibrated, the fate and transport of various COIs will be simulated by introducing various constituents into the

groundwater model at probable source locations. The geochemical parameters for the initial modeling effort will be derived from literature, and from site specific information collected during the Removal Action. Upon completion of the Phase 2 sampling, sample analysis, and pumping test, the model will be updated to include the site specific aquifer characteristics and geochemical data.

The Phase 2 data collection activities will be designed, in part, based on the results of the groundwater model. The model-generated contaminant distribution will be used to determine the number of additional monitor wells to be installed, and to determine the optimum locations for monitor well installation.

The monitor wells installed during Phase 2 and the existing monitor wells will be sampled, and the samples analyzed for the COIs. The Phase 2 analytical methods and parameters will be consistent with the Phase 1 methods and parameters. The analytical methods and parameters may be modified, with EPA approval, based on the results of the Phase 1 sampling.

Upon completion of the Phase 2 sampling, an aquifer pumping test will be conducted, as described in Section 5.7.

2.2.2 Geochemical Sampling and Analysis

PTI Environmental Services, Inc. (PTI) will collect and analyze a variety of geochemical samples. During Phase 1, field redox parameters will be measured to provide contaminant fate input to the groundwater model.

During the Phase 2 monitor well construction, PTI will collect partition coefficient (K_d) samples to provide site-specific K_d data for the COIs. Two types of partition coefficient samples will be collected. Samples referred to herein as "field" K_d samples are samples of aquifer slurry (groundwater with aquifer

soil) which are separated in the field into aquifer solids and groundwater fractions. The field K_d sample locations are selected such that the samples collected will have detectable concentrations of contaminants. The samples referred to herein as "laboratory" or "spiked" K_d samples are comprised of relatively uncontaminated aquifer soils and aquifer groundwater which are spiked in the laboratory with a range of COI concentrations, mixed, separated, and analyzed.

PTI will also collect biological samples from the monitor wells during construction. The goal of the field sampling for the microcosm (biological activity) study is to collect representative samples of aquifer material from zones where the biological community is acclimated to the COIs.

Sample collection for the biodegradation experiment will be conducted according to the following guidelines: 1) care will be taken to ensure that samples are not contaminated with extraneous microorganisms; 2) the samples will be hermetically sealed immediately following collection; and 3) a slurry sample will be collected from below the water table.

2.2.3 Soil Sampling and Analysis

Surficial soil samples will be collected from at least 12 locations within the trailer park located to the north of the site. Additional soil samples will be collected from a depth of 12-inches at 20 percent of the sampling locations. The sampling locations will be selected in the field to characterize stormwater runoff pathways, to determine whether historical stormwater runoff from the site was a contaminant migration pathway. In addition, three (3) background surficial soil samples will be collected from similar areas outside of the potential influence of the site to provide background soil quality data for the Baseline Risk Assessment. Soil samples will be analyzed for purgeable hydrocarbons (EPA Method 8260);

semi-volatile organic compounds (EPA Method 8270); chlorinated pesticides (EPA Method 8080); arsenic (EPA Method 206.2); chromium (EPA Method 200.7); and lead (EPA Method 239.2).

2.3 FIELD AND LABORATORY QUALITY ASSURANCE OBJECTIVES

Quality Assurance/Quality Control (QA/QC) procedures are essential to verification of the achievement of the data quality objectives. QA/QC procedures include such activities as field and laboratory instrument calibration; sample identification, tracking, and chain-of-custody, preventative maintenance; routine audits; the use of specific QA/QC samples to assess precision and accuracy; and record keeping. These procedures for both field and laboratory QA/QC are discussed in detail in the Quality Assurance Project Plan (BCC, 1991) and the Quality Assurance Project Plan Amendment (TASK/PTI, 1993).

Specific samples will be collected to verify the precision and accuracy of data generated during the RI/FS. The estimated number and type of QA/QC samples to be collected and analyzed is provided in Table 2.2.

Specific samples will also be collected to verify the precision and accuracy of analyses performed for the attenuation and degradation parameters. A summary of the regular and QA/QC samples to be collected as part of the determination of degradation and attenuation parameters is presented in Table 2.3.

The types of QA/QC samples for both field and laboratory, are described in Section 2.3 of the Sampling and Analysis Plan (BCC, 1991).

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TABLE 2.2 QUALITY ASSURANCE/QUALITY CONTROL SAMPLES

SAMPLE TYPE	SAMPLES PER SAMPLING ACTIVITY			
	Phase 1	Phase 2 Well	Phase 2	Phase 2
	GW	Construction	GW	Soil
Duplicate	1	0	3	2
Equipment Blank	1	0	3	2
Field Blank	1	0	1	1
Trip Blank	4	1	10	4
Material Blanks				
Drilling Fluid	0	1	0	0
Sand Pack	0	1	0	0
Bentonite	0	1	0	0
Casing/Screen Rinsate	0	1	0	0
EPA Spikes and Blanks	3	0	6	3
TOTAL QA/QC SAMPLES PER				
EVENT	10	5	23	12

**TABLE 2.3 SAMPLE SUMMARY FOR FIELD AND LABORATORY DETERMINATION OF
ATTENUATION AND DEGRADATION PARAMETERS**

Activity	Number of Primary Samples	Travel Blank	Rinsate Blank	Field Blank/ Lab Control	Triplicate	Total Samples
Field Fe(II) and S ⁻	12	0	1	1	1	16
Field D.O., EH, pH, S.C., T	12	0	0	0	1	14
Field K _d (Soil)	8	0	0	0	1	10
Field K _d (Water)	8	1	1	1	1	13
Lab K _d (Soil)	5	0	0	0	1	7
Lab K _d (Water)	5	1	1	1	1	10
Lab Degradation (Method 8080, Water)	18	1	1	1	2	22
Lab Degradation (Method 8270 SIM, Water)	10	0	0	0	2	14
Field Degradation (Methods 8270 SIM, Water)	2	0	0	0	0	2

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CHAPTER 3.0

SAMPLE LOCATIONS, DESIGNATIONS AND FREQUENCY

3.1 SAMPLING LOCATIONS

As discussed in Chapter 2.0, the Phase 1 groundwater sampling will include collection and analysis of samples from the monitor wells which remain on and adjacent to the site. Aquifer redox parameters will be measured in the field in a single event coinciding with the initial sampling of the ten (10) existing wells. Samples will be collected from each well immediately after it is sampled, to avoid the need for additional bailing.

The results of the Phase 1 sampling will be used to select the COIs, and to develop a contaminant fate and transport simulation. This simulation will be used to select the optimum locations for the additional monitor wells which will be constructed and sampled during Phase 2. These wells will be used to characterize the magnitude and extent of the contaminant migration in the surficial aquifer.

It is anticipated that 18 additional stainless-steel monitor wells will be installed during the Phase 2 activities. The total number of wells may be modified based on the results of the modeling. The wells will be installed in clusters of two (2) wells, to include one (1) shallow well and one (1) intermediate depth well per cluster. The shallow wells will be constructed so that the 10-foot well screen intersects the water table. The intermediate depth wells will be constructed so that the 5-foot screen is placed at the base of the surficial aquifer.

One of the intermediate depth wells will be constructed of 4-inch diameter casing and screen, and with a 10-foot length of screen. This well will be

used as a production well for an aquifer pumping test following collection of the Phase 2 samples. In addition, two (2) Hawthorn formation monitor wells will be constructed to monitor the first water producing zone in the Hawthorn formation.

Eight (8) aquifer slurry samples will be collected for determination of soil/water partitioning (K_d), during the installation of the additional wells at the site. The K_d of COIs requires detectable concentrations of COIs in both the aqueous and solid phases. COI concentrations in the 18 proposed new well locations will be estimated from results of the groundwater modeling and initial sampling, and the eight (8) locations having the highest probability of detectable COIs will be selected for collection of K_d samples. These will most likely be near or downgradient from the rinsate ponds which were excavated during the removal action.

PTI will also collect eight (8) aquifer material (i.e., soil) samples (two samples of aquifer material from four locations), and one (1) representative groundwater sample for COI spiking determination of K_d s, and determination of degradation rates. One of the samples from each location will be collected under sterile conditions and sealed immediately on collection for use in the degradation experiments, and the other will be sealed and used for the laboratory-spiking K_d experiments. The wells from which the biodegradation experiment samples are collected will be located hydrologically downgradient from the rinsate pond area (i.e., the suspected source area) to obtain bacteria in the samples that are acclimated to the COIs. The exact location of these wells will be determined subsequent to the first round of groundwater sampling and modeling activities. The other samples of aquifer material collected at each of the four (4) locations will be composited under non-sterile conditions for use in the laboratory-spiking K_d experiments. The representative groundwater sample will be collected from a

single well, the location of which will be determined based on results of the initial round of groundwater sampling and modeling activities.

3.2 SAMPLE DESIGNATION

All samples will be assigned and labeled with a logical code, as described in Section 3.2 of the SAP (BCC, 1991). Samples collected to measure COI migration and degradation will be labeled in the same manner, and as specified below:

CO-XXX-00-11

where CO indicates Chevron Orlando, XXX is the matrix designator, 00 is the sample number, and 11 is the sample depth interval. For water samples, the well identification number or letter is placed in the sample depth field. The matrix designator list will be expanded to include the following designations:

KDW = K_d determination, water fraction;

KDS = K_d determination, solid fraction;

DGW = Degradation sample, water fraction;

DGS = Degradation sample, soil fraction.

The sample number field will be used to identify the QA/QC samples, with the following designations:

TR = Triplicate sample;

TB = Travel blank;

EB = Equipment rinsate blank;

FB = Field blank;

CS = Control sample.

CHAPTER 4.0

ANALYTICAL PROGRAM

4.1 ANALYTICAL PARAMETERS

Groundwater samples collected during the Phase 1 sampling event will be analyzed for purgeable halocarbons and purgeable aromatics (EPA Methods 601/602); semi-volatile organic compounds (EPA Method 625); chlorinated pesticides (EPA Method 608); organophosphate pesticides (EPA Method 614); arsenic (EPA Method 206.2); chromium (EPA Method 200.7); and lead (EPA Method 239.2). Additional groundwater samples will be collected for in-field characterization of the oxidation potential, and will be analyzed at the well head for pH, Eh, ferrous iron [Fe(II)], sulfide, dissolved oxygen, specific electrical conductivity, and temperature. Although the field analyses are classified as level I, all measurements will be quantitative, and instrument response will be verified during field analysis with calibration standards and, where appropriate, spikes.

During the Phase 2 monitor well construction, aquifer matrix and groundwater samples will be collected and analyzed to provide site-specific geochemical data. Each sample of aquifer material collected to determine K_d will generate a solid and aqueous fraction. Both fractions will be analyzed for organochlorine pesticides (EPA SW-846 Method 8080), and for the metals arsenic and chromium (EPA SW-846 Methods 7060 and 6010, respectively). The K_d is determined from the ratios of the concentrations of contaminants in the solid and aqueous fractions.

The samples generated during the laboratory degradation study will be analyzed for organochlorine pesticides (EPA SW-846 Method 8080) at 1, 10, 50,

and 100 days to determine the rate at which these constituents decay under site conditions. The later sampling times may be adjusted based on results of the initial sampling. In addition, ten (10) of the samples from the laboratory degradation experiment and two (2) of the field groundwater samples will be analyzed for lindane degradation products (e.g., 1,2,4-trichlorobenzene, 1,2,3,5- and/or 1,2,4,5-tetrachlorobenzene, 1,2,3,4-tetrachlorobenzene, γ -2,3,4,5,6-pentachlorocyclohex-1-ene, and γ -3,4,5,6-tetrachlorohexene) by EPA SW-846 Method 8270, with the mass spectrometer in selective ion monitoring (SIM) mode.

The complete list of samples to be collected to determine chemical degradation and attenuation parameters is presented as Table 4.1.



The Phase 2 monitor wells and existing monitor wells will be sampled and samples analyzed for the COIs. The analytical parameters and methods for the Phase 2 analysis will be consistent with the Phase 1 methods and parameters. The analytical methods and parameters may be modified, with EPA approval, based on the results of the Phase 1 sampling.

The Phase 2 soil samples will be analyzed for purgeable hydrocarbons (EPA Method 8260); semi-volatile organic compounds (EPA Method 8270); chlorinated pesticides (EPA Method 8080); arsenic (EPA Method 206.2); chromium (EPA Method 200.7); and lead (EPA Method 239.2).

4.2 ANALYTICAL METHOD SUMMARIES

The analytical methods to be used for the Phase 1 groundwater analysis and the Phase 2 soil sample analysis are summarized in Section 4.2 of the SAP (BCC, 1991), except for purgeable hydrocarbons and the metals.

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**TABLE 4.1. SAMPLE DESIGNATION AND ANALYTE LIST FOR DETERMINATION OF
CHEMICAL ATTENUATION AND BIODEGRADATION IN THE SHALLOW AQUIFER**

Sample Designation	Sample Description	Matrix	Analysis
CO-MW-A-01	Existing Well	Groundwater	A,B,C
CO-MW-B-01	Existing Well	Groundwater	A,B,C
CO-MW-C-01	Existing Well	Groundwater	A,B,C
CO-MW-D-01	Existing Well	Groundwater	A,B,C
CO-MW-E-01	Existing Well	Groundwater	A,B,C
CO-MW-F-01	Existing Well	Groundwater	A,B,C
CO-MW-G-01	Existing Well	Groundwater	A,B,C,E
CO-MW-H-01	Existing Well	Groundwater	A,B,C,E
CO-MW-I-01	Existing Well	Groundwater	A,B,C
CO-MW-J-01	Existing Well	Groundwater	A,B,C
CO-MW-K-01	Existing Well	Groundwater	A,B,C
CO-M2-L-01	Existing Well	Groundwater	A,B,C
CO-MW-EB-01	Equipment Rinsate Blank	Ultra-pure Water	A
CO-MW-TR-01	Triplicate, Existing Well	Groundwater	A,B,C
CO-MW-TR-02	Triplicate, Existing Well	Groundwater	A, B, C
CO-MW-FB-01	Field Blank	Ultra Pure Water	A,B,C
CO-KDS-01-01	Field K _d	Soil	D,F
CO-KDW-01-01	Field K _d	Groundwater	D
CO-KDS-02-01	Field K _d	Soil	D,F
CO-KDW-02-01	Field K _d	Groundwater	D
CO-KDS-03-01	Field K _d	Soil	D,F
CO-KDW-03-01	Field K _d	Groundwater	D
CO-KDS-04-01	Field K _d	Soil	D,F
CO-KDW-04-01	Field K _d	Groundwater	D
CO-KDS-05-01	Field K _d	Soil	D,F
CO-KDW-05-01	Field K _d	Groundwater	D
CO-KDS-06-01	Field K _d	Soil	D,F
CO-KDW-06-01	Field K _d	Groundwater	D
CO-KDS-07-01	Field K _d	Soil	D,F
CO-KDW-07-01	Field K _d	Groundwater	D
CO-KDS-08-01	Field K _d	Soil	D,F
CO-KDW-08-01	Field K _d	Groundwater	D

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TABLE 4.1 (cont.)

Sample Designation	Sample Description	Matrix	Analysis
CO-KDS-TR-01	Triplicate K _d	Soil	D,F
CO-KDW-TR-01	Triplicate K _d	Groundwater	D
CO-KDS-TR-02	Triplicate K _d	Soil	D,F
CO-KDW-TR-02	Triplicate K _d	Groundwater	D
CO-KDW-EB-01	Equipment Rinsate	Ultra-pure Water	D
CO-KDW-FB-01	Field Blank	Ultra-pure Water	D
CO-KDW-TB-01	Travel Blank	Ultra-Pure Water	D
CO-DGW-A-01	Degration Matrix	Groundwater	D
CO-DGW-01-01	Laboratory Degradation	Groundwater	D,E
CO-DGW-01-02	Laboratory Degradation	Groundwater	D
CO-DGW-01-03	Laboratory Degradation	Groundwater	D
CO-DGW-01-04	Laboratory Degradation	Groundwater	D,E
CO-DGW-02-01	Laboratory Degradation	Groundwater	D,E
CO-DGW-02-02	Laboratory Degradation	Groundwater	D
CO-DGW-02-03	Laboratory Degradation	Groundwater	D
CO-DGW-02-04	Laboratory Degradation	Groundwater	D,E
CO-DGW-03-01	Laboratory Degradation	Groundwater	D,E
CO-DGW-03-02	Laboratory Degradation	Groundwater	D
CO-DGW-03-03	Laboratory Degradation	Groundwater	D
CO-DGW-03-04	Laboratory Degradation	Groundwater	D,E
CO-DGW-04-01	Laboratory Degradation	Groundwater	D,E
CO-DGW-04-02	Laboratory Degradation	Groundwater	D
CO-DGW-04-03	Laboratory Degradation	Groundwater	D
CO-DGW-04-04	Laboratory Degradation	Groundwater	D,E
CO-DGW-TR-01	Triplicate, Lab Degradation	Groundwater	D,E
CO-DGW-TR-02	Triplicate, Lab Degradation	Groundwater	D,E
CO-DGW-TR-03	Triplicate, Lab Degradation	Groundwater	D,E
CO-DGW-TR-04	Triplicate, Lab Degradation	Groundwater	D,E
CO-DGW-SC-01	Sterile Control, Degradation	Groundwater	D,E
CO-DGW-SC-02	Sterile Control, Degradation	Groundwater	D,E
CO-DGW-SC-03	Lab Control, Standard	Spiked Water	D

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TABLE 4.1 (cont.)

Sample Designation	Sample Description	Matrix	Analysis
CO-DGW-EB-01	Equipment Rinsate (Lab)	Ultra-pure Water	D
CO-DGW-TB-01	Travel Blank (Lab)	Ultra-pure Water	D
CO-DGW-A-01	Field Degradation	Groundwater, Baseline	D,E
CO-DGW-B-01	Field Degradation	Groundwater	E
CO-DGW-A-01	Lab Degradation	Groundwater, Spiked	D
CO-DGW-A-02	Lab Degradation	Groundwater, Spiked	D

Key: A. Ferrous iron (aqueous)

B. Dissolved sulfide (aqueous)

C. Field D.O., pH, Eh, conductivity, and temperature

D. EPA Method 8080, organochlorine pesticides

E. EPA Method 8270 in selective ion monitoring (SIM) for degradation products.

F. EPA Method 9060, Total organic carbon (TOC) in soil

Purgeable hydrocarbon analysis by EPA Method 8260 is a purge and trap technique for the determination of a number of purgeable organic compounds that are partitioned and analyzed by gas chromatography/mass spectrometry (GC/MS). The chemical analysis for arsenic and lead will be accomplished by atomic absorption spectrophotometry. Chromium will be analyzed by Inductively Coupled Plasma (ICP). Also, second column confirmation will be utilized for the EPA Method 601 and 602 analyses of the Phase 2 groundwater samples.

Temperature, pH, Eh, specific electrical conductivity, and dissolved oxygen will be measured with the appropriate electrodes in a flow-through cell apparatus to prevent contact with the atmosphere. The field methods are described in detail in PTI's Standard Operating Procedures (Appendix A), and are summarized below.

- Redox potential, or Eh, will be measured electrometrically at the well head with a platinum electrode and a Ag/AgCl reference electrode, calibrated against ZoBell's solution (Nordstrom 1977).
- Dissolved ferrous iron, Fe(II), will be determined colorimetrically with a Hach DR-2000 spectrophotometer at the well head on a filtered sample of groundwater.
- Dissolved sulfide will be determined at the well head on unfiltered samples of groundwater using a sulfide-specific electrode.
- Dissolved oxygen (DO) will be determined with an oxygen-permeable membrane electrode in the flow-through cell at the well head.

CHAPTER 5.0**SAMPLING EQUIPMENT AND PROCEDURES**

5.1 GENERAL

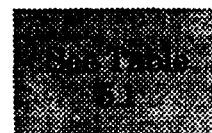
Sampling procedures for each sample matrix are outlined in Chapter 5.0 of the SAP (BCC, 1991). Samples will be collected, documented, and transported in accordance with the procedures specified in the Environmental Compliance Branch Standard Operating Procedures and Quality Assurance Manual, February 1991, EPA Region IV. Sampling procedures which differ from those specified in the SAP (BCC, 1991) are summarized below.

5.2 FIELD REDOX DETERMINATION

Electrode analysis for pH, Eh, temperature, specific conductivity, and dissolved oxygen will be conducted in a flow-through cell under zero-headspace conditions to minimize alteration of the aquifer conditions. Immediately after purging the wells (SAP Section 5.5.2, BCC 1991), oxygen-impermeable tubing connected to a Geofilter® peristaltic pump will be inserted to several feet below the water surface and within the screened interval of the well. This intake location minimizes collection of water from the reoxygenating zone at the surface. Water will be pumped directly into the bottom of a polycarbonate flow-through cell, where the pH, Eh, conductivity, temperature, and dissolved oxygen electrodes are mounted in air-tight fittings. Groundwater will be allowed to fill the cell, all bubbles bled off from the electrode fittings, and pumping will continue until the electrode readings stabilize (typically after approximately two additional cell volumes of groundwater have flushed through the system). Electrode

measurements will be recorded while the water is actively flowing through the cell.

Ferrous iron [Fe(II)] will be determined colorimetrically following complexation by 1,10-phenanthroline. Groundwater will be retrieved from the well with a peristaltic pump, passed through an in-line 0.45- μ m filter, and the sample collected by opening a glass AccuVac ampule under the surface of the water in the beaker, as described in the Appendix A SOP 2. The field filtration is conducted because the colorimetric method is more accurate with filtration.



Ferrous iron method detection limits are approximately 0.01 mg/L. The equipment to be used for field determination redox parameters is listed in Table 5.1.

5.3 GEOCHEMICAL SAMPLING

To avoid biological contamination of the aquifer material, a stainless-steel split spoon, containing three (3) 6-inch stainless steel sampling tubes, will be used for collection of aquifer matrix samples. The sampling tubes will be sterilized (by autoclave), capped with sterilized (by ultraviolet irradiation) end caps, sealed in a plastic bag, and shipped to the field. A hollow-stem auger will be used to drill from the ground surface to a depth of at least 1-foot below the water table. Prior to sampling, the split spoon will undergo standard decontamination procedures, as outlined in Section 5.9.1 of the SAP (BCC, 1991), followed by a final sterilizing rinse in technical-grade isopropanol. The sterilized sampling tubes will be placed into the split spoon by personnel wearing clean latex or vinyl gloves. The sample will then be collected by driving the split spoon into the aquifer material below the water table. A total of eight (8) samples (two from each of the four selected locations) will be collected from individual wells in this manner.

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TABLE 5.1. TABLE OF EQUIPMENT FOR FIELD DETERMINATION OF AQUIFER REDOX PARAMETERS

General:

Kimwipes
 250-mL nalgene beaker (2)
 100-mL graduated cylinder
 Deionized water
 Deionized-water squirt bottle
 250-mL volumetric flask
 Polycarbonate flow-through cell
 Peristaltic pump
 0.45 μ m in-line filter setup for pump
 Flexible hose for peristaltic pump (100 ft)
 Portable 12-V automobile battery
 Adjustable wrench
 Microliter pipettes and tips
 10 100- μ L
 100 1000- μ L
 1 10-mL
 125-mL nalgene containers with caps (10)
 Thermometer
 Calculator
 Duct tape
 Screw driver
 Hose clamps
 Voltmeter (accurate to ± 1 mV)
 10 percent HCl (50 mL)
 Sample labels
 Custody seals

Ferrous Iron Analysis:

HACH DR-2000 spectrophotometer
 Fe(II) standard solution (1–2 mg/L ferrous iron, pH 2)
 HACH Ferrous iron accuvacs

Sulfide Analysis:

Sulfide anti-oxidant buffer (SAOB, pH 11)
 Sulfide selective electrode
 Sulfide standard (1000 mg/L)

Field Parameters:

Glass combination pH electrode
 pH meter
 pH buffer standards (pH 4, 7, and 10)
 Combination platinum and reference electrode
 ZoBell's solution
 Membrane-type dissolved oxygen probe
 Dissolved oxygen meter
 Dissolved oxygen electrode calibration sleeve
 Specific conductivity meter and probe

Immediately on retrieval of the split spoon, the stainless steel tubes will be removed, and the ends sealed with air-tight caps and a parafilm wrap. Two tubes from each of the four split-spoons sampling locations will be dedicated to the biodegradation experiment, while the third will be used to form the K_d composite. The tubes will be labeled, double wrapped in plastic bags, and shipped on ice (under chain of custody) by overnight courier to PTI's Boulder, Colorado laboratory for processing.

The water for the K_d experiment (10 L) will be collected in five pre-cleaned, 2-L glass bottles, while the water for the biodegradation experiment (26 L) will be collected in 13 pre-cleaned, sterilized (by autoclave), 2-L amber glass bottles. One well-casing volume will be purged from the well by bailing, after which the samples will be collected using a peristaltic pump and clean Tygon® tubing inserted down the well to below the water level. Each 2-L glass bottle will be filled with groundwater, capped, and sealed with parafilm. In the event that anoxic conditions are encountered in the aquifer, water for the biodegradation experiment will be collected by filling the containers from the bottom, and allowing at least two times the volume of the container to flush through to exclude atmospheric oxygen before sealing the bottle under zero-headspace conditions. The groundwater samples for the K_d and microcosm study will be shipped on ice and under chain of custody by overnight courier to PTI's Boulder laboratory.

Two (2) wells will be sampled by the above method (2 L each in precleaned glass bottles) during field activities and analyzed by EPA Method 8270 in the selective ion monitoring (SIM) mode for lindane daughter products, which include 1,2,4-trichlorobenzene, 1,2,3,5- and/or 1,2,4,5-tetrachlorobenzene, 1,2,3,4-tetrachlorobenzene, γ -2,3,4,5,6-pentachlorocyclohex-1-ene, and γ -3,4,5,6-tetrachlorohexene (Howard 1991). The analyte list will be limited to the availability of

standards for the calibration of the mass spectrometer. Results of these analyses will facilitate estimation of the extent of in situ lindane biodegradation occurring in the aquifer.

5.3.1 Separation of Soil and Water for Determination of K_d

Direct measurement of the soil/water partition coefficient, or K_d , requires detectable concentrations of the COIs both in the liquid and solid fractions of the aquifer slurry. The field zero-headspace extractor (ZHE) method for determining K_d uses pressure filtration of aquifer materials to separate the water from the solids. The aqueous and solid phases are then analyzed separately for COIs. ZHEs were designed to evaluate volatile constituents in the EPA's toxicity characteristic leaching procedure (TCLP) and are widely used in laboratory settings. The ZHE consists of a 6-inch-long cylinder, an airtight movable piston in a base, and a screened filter holder at the top. When sealed, up to 50 psi of air may be applied to the cylinder to force the water through the filter. Use of a zero headspace device avoids loss of volatile constituents from the sample, thereby permitting use of this method on volatile and semi-volatile constituents. The ZHE will be decontaminated before each use. Decontamination procedures are identical to those for other field sampling equipment (BCC 1991, Section 5.9.1).

Samples of aquifer material are obtained by drilling to below the water table with a hollow-stem auger, withdrawing the auger approximately 6 inches to allow the borehole walls to cave in, and retrieving samples of the aquifer/groundwater slurry with a stainless steel or Teflon® bailer. Aquifer slurry samples are placed immediately into a zero headspace extractor (ZHE).

When filled to within 5 cm of the top with slurry, the ZHE is capped, and the pressure cylinder attached to a portable compressed-air source. Any air space above the sample is immediately forced out by applying air pressure to the

piston. The aqueous samples are collected in an 80-mL glass and Teflon® syringe attached directly to the ZHE to maintain zero headspace conditions. Aqueous samples can then be placed immediately into glass sample containers containing the required preservatives. Sample containers will be 40 mL for volatile organic analysis and 125 mL for pesticide analysis (e.g., EPA Method 8080).

The ZHE is then opened, and the solid fraction immediately placed in glass sample containers by hand using a stainless steel spatula. As with the aqueous fraction, containers will be 40 mL for volatiles and 125 mL for pesticides. In most cases, the high water content of the solids allows the removal of all visible headspace from the containers. Following collection, samples are stored in coolers at 4° C and shipped overnight to Pace, Inc. for chemical analysis.

The aqueous and solid fractions will be analyzed by EPA Method 8080 (gas chromatography, electron capture detector for organochlorine pesticides). In addition, the solid fraction will be analyzed for moisture content (SOP 5, Appendix A) to allow determination of a dry-weight K_d . Following analyses for volatiles, the remaining solid samples will be sent to Huffman Laboratories in Golden, Colorado, for determination of total organic carbon (TOC, EPA Method 9060), to allow comparison of the measured K_d s to the theoretical values predicted from the TOC values.

The laboratory experimentation for determination of K_d is similar to the field ZHE procedure in terms of sample collection and analysis. Separate samples of aquifer material and groundwater are added to the decontaminated ZHE in known amounts (gravimetrically) to obtain a total volume of approximately 1.5 L in the ZHE. The actual soil/water ratio should be as high as possible to assure collection of a 500-mL aqueous sample from the pressure filtration. The slurry is then spiked with the COI at the desired concentration, either by volumetric addition of a solvent carrier containing the COI, or by direct

addition of a gravimetrically determined mass of COI. The mass of the COI spike will be determined following evaluation of the anticipated groundwater concentrations. The COI spike concentrations will be selected so that the resulting K_d s can be applied to the SUTRA modeling under site-specific conditions, i.e., the aqueous concentration in the equilibrated sample should range between the instrument detection limit for that analyte (e.g., 0.5 $\mu\text{g/L}$ for lindane in a 100 mL sample) and two times above the upper limit measured in the site groundwater.

Following loading, the ZHE is sealed immediately and tumbled for 24-hours at $20\pm 4^\circ\text{C}$, to equilibrate COIs between the solid and aqueous phases. The samples of solid and aqueous fractions are then collected and analyzed following procedures identical to those described above for collection of ZHE samples in the field. Equipment required is listed in Table 5.1.

The laboratory K_d experiments will include a total of eight (8) equilibrium reaction, and the aqueous and solid fractions will be analyzed in each equilibration. One (1) reaction will measure COI partitioning on an unspiked sample of the composite soil, and four (4) reactions will be spiked with COIs at varying concentrations to obtain the desired aqueous concentration range. Finally, three (3) splits of the soil retrieved from the equilibration reaction that received the highest COI spike concentration will then be re-equilibrated with clean groundwater to measure COI desorption from the soil. In these desorption experiments, the ratio of soil to groundwater will be varied, so that the COI concentrations in the groundwater and soil fractions are at least five times above the analytical detection limit (e.g., for lindane, detection requires approximately 0.025 μg lindane in the sample; thus the soil/water ratio should be chosen such that the water and the soil fractions each contain at least 0.125 μg of lindane). Final ratios will be selected from the theoretical COI K_d determined from the organic carbon content of the composite sample.

5.3.2 Laboratory Degradation Determinations

Due to the dependence of the required experimental and analytical methods on the particular COIs identified, the scope of the biodegradation experiments has been written assuming that lindane will be the primary COI. The laboratory microcosm study will start with multiple containers (either aerobic or anaerobic, depending on conditions determined in the aquifer) that contain accurately measured amounts of aquifer material, groundwater, and lindane. Each reaction bottle containing mixtures of aquifer material and water will then be spiked with lindane, to achieve a lindane concentration approximately equal to the average concentration measured in the groundwater at the site. In the event that anoxic conditions exist in the aquifer, sample handling and experimental setup will be conducted in a sterile, nitrogen-atmosphere glove box, to avoid contamination by either oxygen or extraneous microorganisms. However, if oxygenated conditions are appropriate, the sample handling and experimental setup will be performed in a laboratory hood that has been rendered abiotic by ultraviolet irradiation. The laboratory degradation will yield the rate of lindane degradation, both biotic and abiotic.

On receipt at PTI's Boulder laboratory, a sample of the groundwater will be analyzed for sulfate, nitrate, phosphate, pH, and total organic carbon, to quantify the nutrients that are present initially in the groundwater. Unopened groundwater bottles and aquifer material samples will be placed in the sterile glove box or hood, where the stainless-steel tubes will be opened, and a representative sample of each solid material collected in a pre-cleaned glass sample bottle, and analyzed for nitrate, phosphate, total organic carbon, and bulk density to determine biological nutrients present in the aquifer material.

Twenty (20) sterilized 1-L glass bottles will be weighed empty (including cap), and 100 g of wet aquifer material (4 bottles of 3 aquifer materials, and 8 bottles of 1 aquifer material) will be added to each. Each microcosm will be filled with groundwater (approximately 900 mL) and sealed with impermeable caps (unless the redox measurement of the aquifer indicates oxygenated conditions, in which case, oxygen-permeable lids will be used). The microcosm vessels will be weighed to determine the mass of water and aquifer material in each container, and the percent moisture of the aquifer material will be determined (percent weight loss on drying at 105°C for 24 hours). Two additional microcosm vessels (abiotic) will be treated as above, but sodium azide (2,000 mg/L) will be added to inhibit any microbial activity and allow determination of abiotic degradation. Two final microcosm vessels (controls) will be filled with 1 L of type 2 deionized water. These procedures will provide 24 microcosm vessels with the following contents: 1) 4 bottles each of 4 aquifer materials for determination of lindane biodegradation at 4 time points (16 bottles total), 2) 1 aquifer material for triplicate analyses at two time points (4 total bottles), 3) 2 bottles sterilized with sodium azide for determination of abiotic degradation at two time points (2 total bottles), 4) 1 travel blank, 5) 1 rinsate blank, and 6) 1 bottle with deionized water spiked with known concentration of lindane (laboratory control samples, LCS).

After sealing, the microcosm reactors will be spiked with equivalent volumes of lindane to achieve fluid lindane concentrations approximately equal to average concentrations in the groundwater plume. The vessels will be rotated end-over-end for 24 hours to establish lindane equilibrium between the fluid and solid phases. After establishing equilibrium, samples will be collected on the first day of the experiment by emptying the contents of one bottle of each aquifer material into a zero-headspace extractor (ZHE) and separating the fluid from the solid fraction. The fluid fractions of the Day 1 samples will be placed in precleaned glass bottles under zero-headspace conditions and sent to PACE laboratories for lindane analysis by EPA Method 8080 to establish initial condition.

The vessels will be stored in the dark at approximately 25° C, and one bottle from each aquifer material type will be opened at 10, 50, and 100 days. The fluid and solid fractions will be separated using the ZHE, and the fluid fraction analyzed for lindane by EPA Method 8080.

The time points in the lindane degradation study were chosen based on published studies of lindane biodegradation in sewage sludges, which indicated half-lives on the order of 25–30 days (Jacobson, et al., 1991; McTernan and Pereira 1991). The samples collected after 50 and 100 days should thus indicate quantifiable degradation losses.

Concentrations of known daughter products formed during biodegradation, which include 1,2,4-trichlorobenzene, 1,2,3,5- and/or 1,2,4,5-tetrachlorobenzene, 1,2,3,4-tetrachlorobenzene, γ -2,3,4,5,6-pentachlorocyclohex-1-ene, and γ -3,4,5,6-tetrachlorohexene (Howard 1991), will be determined by EPA Method 8270, using the SIM, for all four of the aquifer material types at 1 and 100 days. For two of the aquifer materials at 100 days, the EPA Method 8270 SIM runs will be performed in triplicate. One (1) sterile sample will be analyzed for lindane and its daughter products at 1 and 100 days to determine the abiotic component of degradation. Finally, one groundwater spiked with lindane, without aquifer material, will be analyzed for lindane at 1 and 100 days to measure the fluid degradation rate in the absence of aquifer material. These experiments will result in 32 Method 8080 analyses for lindane, and 10 Method 8270 analyses for biodegradation daughter products.

Biodegradation will be assessed by comparing the disappearance of lindane in the biodegradation vessels versus the abiotic controls and spiked method blanks over time. The determination of lindane daughter products will provide verification of any biodegradation occurring in the vessels, and may

indicate the degradation pathway, providing valuable information regarding selection of appropriate remedial alternatives.

5.4 MONITOR WELL CONSTRUCTION

The new monitor wells will be constructed following the procedures defined in Section 5.3 of the SAP (BCC, 1991). The shallow and intermediate depth monitor wells will be constructed of stainless steel casing, screen, and end plugs using hollow-stem auger drilling techniques. One of the intermediate depth wells will be constructed of 4-inch diameter stainless steel screen and casing, and with a 10-foot length of screen. This well will be used for a production well during the aquifer pumping test. It may be necessary to install temporary piezometers for observation wells, if the selected production well is not close enough to other monitor wells. Temporary piezometers will be constructed of 2-inch PVC casing and screen, installed to a depth at least 10-feet below the water table.

The Hawthorn formation monitor wells will be constructed using mud-rotary drilling techniques, and with double casing, to prevent the potential for interchange of water and contaminants between the aquifers. The outer casing of the Hawthorn formation monitor wells will be 8 to 10-inch PVC. The outer casing will be set into a 12-inch borehole constructed to a depth of approximately 40-feet (5 to 10 feet into the top of the confining layer). The casing will be pressure grouted into place, and the grout allowed to cure for 72-hours. A 2-inch diameter pilot hole will be drilled through the outer casing, to the depth of the first water producing zone in the Hawthorn formation. The pilot hole will be over-drilled to approximately 6-inches in diameter, and the 2-inch diameter stainless steel casing and screen installed to the selected monitoring zone. The well will be completed with gravel pack, a bentonite seal, and cement grout, as described in the SAP (BCC, 1991). The gravel pack, bentonite seal, and cement

grout will be tremied into place, to ensure that these materials are placed at the proper depths.

All new monitor wells will be developed following construction, as described in Section 5.3.2 of the SAP (BCC, 1991).

5.5 MONITOR WELL SURVEYING

Upon completion of monitor well construction, the elevation of the top-of-casing for each monitor well will be measured by a surveyor registered in the State of Florida. A base map will be prepared to depict the area of well installation, to include existing wells, property boundaries, drainage features, and major structures.

5.6 GROUNDWATER SAMPLING

All new and existing monitor wells will be sampled prior to aquifer testing, in accordance with the procedures defined in Section 5.5 of the SAP (BCC, 1991).

5.7 AQUIFER TESTING

An aquifer pumping test will be conducted to determine site-specific characteristics of the surficial aquifer. Several pumping test simulations were run using the Theis Well Field Model (Prickett, 1987) to determine the optimum pumping duration, rate, and well spacing. Hydraulic conductivity values from onsite slug testing, and literature values for storativity were used in the simulations.

The pumping test will be conducted in an area of minimum contamination (if possible). One of the new intermediate depth monitor wells will be selected as a production well, and will be constructed of 4-inch diameter casing and screen. The screen will be 10-foot in length to minimize well losses. The well screen will be selected based on sieve analysis of split-spoon samples collected from the production zone to maximize well efficiency. Two observation wells will be used, and may be existing monitor wells (if close enough) or temporary PVC piezometers. The observation wells will be at least 36 feet, and no more than 72 feet from the production well. If monitor well clusters are located within the acceptable distance, the water level response in both wells in the cluster will be measured.

The drawdown in observation wells within 36 to 72-feet of the production well will stabilize within 6 to 8 hours of the start-up of the pumping test, with a pumping rate ranging between 3 and 5 gallons per minute. The groundwater will be pumped into a "frac tank" or tanker truck for.

At the completion of the test, the collected groundwater will be analyzed to determine the appropriate treatment or disposal method. The collected groundwater will be handled in one of the following ways:

- The groundwater may be treated onsite with a portable granular activated carbon unit. If onsite treatment is utilized, the water will be treated and held in a second tank until it can be sampled and analyzed. The treated water will then be used to irrigate the site during the subsequent dry season.
- The groundwater may be utilized for treatability studies, if the contaminant concentrations are acceptable, and if treatability studies are conducted.

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- The groundwater may be discharged onsite if the contaminant concentrations do not exceed the maximum contaminant levels. The discharge would occur by way of low-volume spray irrigation during the dry season.
- The groundwater may be transported offsite for disposal at an EPA approved liquid waste disposal facility.

A memorandum will be prepared at the completion of the pumping test and effluent sampling and analysis, to describe the intended fate of the pumping test water. EPA's approval of the use or disposal of the pumping test water will be obtained before the water is removed from or applied to the site.

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CHAPTER 6.0

SAMPLE HANDLING

Sample handling, labeling, and shipping will be conducted in accordance with the procedures specified in Chapter 6.0 of the SAP (BCC, 1991).

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CHAPTER 7.0

INVESTIGATION DERIVED WASTE HANDLING AND DISPOSAL

Investigation derived wastes will be handled in accordance with Chapter 7.0 of the SAP (BCC, 1991).

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CHAPTER 8.0

LABORATORY QUALITY ASSURANCE

Laboratory quality assurance/quality control procedures and goals are described in detail in the Quality Assurance Project Plan (BCC, 1991).

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3 2 0047

APPENDIX A

PTI ENVIRONMENTAL SERVICES, INC.

STANDARD OPERATING PROCEDURES

**STANDARD OPERATING PROCEDURE FOR ELECTRODE MEASUREMENT OF
THE OXIDATION-REDUCTION
POTENTIAL (Eh) OF GROUNDWATER**

SOP-1

The following procedure is for direct measurement of oxidation potential in groundwater using a platinum combination electrode.

FIELD PROCEDURES

1. Place platinum combination oxidation-reduction potential (ORP) electrode into flow-through cell.
2. Affix the pump discharge tube to the bottom of the flow-through cell, and allow cell to fill and overflow. Bleed off any excess air in the top of the cell.
6. When reading drifts less than 10 mV in one minute, read and record ORP to nearest 10 mV. Record any measurement problems, such as an unstable reading.

CALIBRATION

1. On the morning of sampling, check sensitivity of electrodes.
 - Connect ORP electrodes to meter; immerse electrodes in a beaker of tap water; turn on meter.
 - Add a drop of dilute acid to beaker, swirl to mix.
 - If the reading increases sharply, electrode is sensitive and operating properly.
 - If little or no response is observed, substitute spare electrodes for that day's activities and clean the ORP electrodes. Cleaning procedure:
 - a. Drain filling solution from outer portion of electrode body and refill with fresh solution.
 - b. If precipitate is evident, or if electrode still does not respond properly, remove the sleeve from the inner electrode.
 - c. Rinse both parts with distilled water and allow to air dry.
 - d. Reassemble electrode and refill with filling solution.

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2. During the period when Eh measurements are being taken, check electrodes against a standard solution at the beginning of each day.
 - Rinse electrode in distilled water and immerse in ferricyanide-/ferrocyanide solution (ZoBell's solution).
 - Measure potential in millivolts. The measured potential should be $+439 \pm 20$ mV. If it deviates from this value by more than 30 mV, check the electrode outer chamber for precipitate. Clean the electrode if required. If there is no indication of electrode clogging, but the reading is off, perform the troubleshooting procedures given in the Owner's Manual for the pH/volt meter.
3. Check the level of filling solution in the outer chamber of the electrode. The level should be within 0.5 inch of the filler hole. If required, add reference filling solution: 2 molar KCl saturated with AgCl (Orion 90-00-01).

REAGENTS

1. ZoBell's Solution:

Mix a solution that is 3.33×10^{-3} molar $K_4Fe(CN)_6$, 3.33×10^{-3} molar $K_3Fe(CN)_6$, and 0.1 molar KCl using distilled water.

CALCULATIONS

The theoretical redox potential of the ZoBell's solution, $E_{ZoBell,theoretical}$ (in volts), relative to the normal hydrogen electrode is:

$$0.43028 - 2.5157 \times 10^{-3}(t-25) - 3.7979 \times 10^{-6}(t-25)^2$$

where t is temperature ($^{\circ}C$).

The potential of the reference electrode, $E_{reference}$, is the measured potential in the zobell's solution minus the theoretical potential of the ZoBell's solution at the temperature of the measurement:

$$E_{reference} = E_{zobell,theoretical} - E_{ZoBell,meas}$$

The Eh of the sample is then:

$$E_h = E_{sample,meas} + E_{reference}$$

3 2 0050

ADDITIONAL INFORMATION

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STANDARD OPERATING PROCEDURE FOR DETERMINATION OF FERROUS IRON IN GROUNDWATER WITH A HACH DR-2000

SOP-2

The following method uses the HACH DR 2000 spectrophotometer to measure dissolved ferrous iron in groundwater.

- 1) Select the pre-programmed procedure for ferrous iron determination with AccuVac ampules (refer to the DR 2000 manual for basic operation).
- 2) Affix the outflow from the well pump to a 0.45- μ m in-line filter, and collect filtered water in a decontaminated plastic or glass beaker.
- 3) When the beaker is full, invert an AccuVac sample cell into the sample solution and apply pressure until the tip breaks and the sample is drawn into the cell (make sure that the solid reagent is clear of the neck of the AccuVac prior to breaking the tip; reagent caught in the neck will inhibit flow of sample into the AccuVac).
- 4) Invert the filled AccuVac several times to ensure complete mixing, and allow the contents to react for the time specified in the procedure being used (3 minutes for ferrous iron).
- 5) Wipe any moisture or fingerprints from the outside of the AccuVac.
- 6) The DR 2000 is zeroed by pouring sample into a clean, reagent-free AccuVac. Place the blank sample into the DR 2000, and press the "zero" button. The instrument will read "0.00" and is now ready for sample analysis.
- 7) Place the ferrous iron ampule in the spectrophotometer cell and press "read." Ferrous iron concentration is displayed in mg/L.
- 8) If the sample exceeds the linear range (e.g., above 3.5 mg/L iron), then the sample must be diluted by pipetting a known volume of sample into a clean beaker, then adding a known amount of deionized water to the sample. Once diluted, the sample should be collected with the AccuVac within 20 seconds to avoid iron oxidation.

QA PROCEDURES

- 1) Prior to analysis, a calibration check must be performed using a standard of concentration similar to the midpoint of the calibration curve. The standard should be prepared by diluting a certified standard from a reputable supplier (e.g., traceable source). The

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calibration check must fall within ± 10 percent of the expected value; otherwise, the standard must be remixed, the instrument recalibrated, and the analysis repeated. The calibration check should be performed once for every 20 samples analyzed.

- 2) A duplicate analysis should be performed on 1 in 20 samples to evaluate accuracy and precision of the instrument.
- 3) A blank analysis should be performed after each 10 samples analyzed. The blank value should be less than 5 times the IDL listed in the DR 2000 operation manual for the analysis in question. If the blank analysis provides a value above this limit, the analytical method should be evaluated for possible contamination of samples and standards, and the instrument calibration should be checked to determine whether the baseline has shifted.
- 4) An analytical spike should be prepared and analyzed on 1 in 20 samples to check for matrix interferences. For samples with spike recoveries < 80 percent or > 120 percent, a standard additions curve must be developed to compensate for matrix effects.

**STANDARD OPERATING PROCEDURE FOR DETERMINING SULFIDE IN
GROUNDWATER WITH A SULFIDE-SELECTIVE ELECTRODE****SOP-3**

The following procedure is for analysis of sulfide in water using an Orion solid state sulfide-selective electrode (AgS) in conjunction with a voltmeter. The reported working range of this method is 0.003 to 32,000 mg/L, though calibration in the field indicates that the practical quantitation range under field conditions is more typically 1 to 10,000 mg/L.

1. Immediately on retrieval of the groundwater sample from the well, an unfiltered aliquot is mixed at a 1:1 ratio with a pH-11 ascorbic acid sulfide anti-oxidant buffer (SAOB), which converts all sulfide into the S⁻² form and prevents subsequent reactions with atmospheric oxygen.
2. The electrode is placed into the solution, and the potentiometric response recorded when the electrode stabilizes (typically after 30 seconds). Note electrode response to the nearest 1 mV.

QA Procedures:

1. Within 4 hours of measuring the sample response, the electrode response should be calibrated by measuring a response solution mixed from a standard Na₂S solution (available from HACH Company, Loveland, Colorado).
2. Prepare fresh sulfide standards each day in SAOB that brackets the concentration range anticipated in the field. Standard concentrations are separated by a factor of 10 (e.g., 0.1 mg/L, 1 mg/L, 10 mg/L, etc.).
3. From the response to the standard solutions, plot log(sulfide concentration) versus electrode response (mV), and determine the slope and intercept of this line. (The ideal slope should be 30 mV for each 10× change in sulfide concentration.)
4. The log of the sulfide concentration in the unknown sample is read from the calibration plot of the standards.

STANDARD OPERATING PROCEDURE FOR DETERMINATION OF DISSOLVED OXYGEN IN WATER WITH A MEMBRANE ELECTRODE**SOP-4**

The Orion portable dissolved oxygen meter is a hand-held instrument that measures both oxygen and temperature. The meter is supplied with an ultra-stable dissolved oxygen (DO) sensor that incorporates temperature compensators. The detection limit for dissolved oxygen is 0.1 mg/L.

PREPARATION FOR USE

The probe is delivered with a calibration sleeve containing distilled water covering the membrane. The meter is calibrated to water-saturated air with the electrode in the sleeve. The sponge in the tip of the cap should be kept wet to keep the membrane moist whenever the probe is not in use.

1. Connect the oxygen electrode to the meter, and place the electrode in the calibration sleeve.
3. Set mode to mg/L and allow the electrode to polarize (this takes about 10 minutes). To avoid waiting for the electrode to polarize each time the instrument is used, it should be stored with the electrode permanently connected. The instrument keeps the electrode polarized even when switched off.
4. After polarization, set the mode to CALIBRATE with the electrode in the calibration sleeve. The meter will display the DO concentration, in mg/L equivalents to which it has been calibrated.
5. The instrument is now ready for use in either PERCENT SATURATION or mg/L without further calibration. The automatic temperature compensation in the electrode corrects for the change in membrane permeability with temperature, and for the change in the solubility of oxygen in water with temperature. No calibration is required for temperature measurement.
6. If desired, a solution of zero-oxygen concentration can be prepared with 2-percent w/v solution of sodium sulfite. Other alternatives are adding a small amount of solid sodium dithionite to water, or adding solid sodium sulfite and a trace of cobaltous chloride as a catalyst. Both of these will remove dissolved oxygen fairly rapidly. This step is not necessary, but verifies the ability of the meter to identify low oxygen concentrations.

If the electrode contains bubbles under the membrane, unscrew the tip, remove the membrane while holding the membrane module in a vertical position, and fill

the electrode with O₂ electrolyte (provided with the probe). Replace the membrane while still holding the membrane module in the vertical position, and screw the probe slowly down onto the thread, allowing excess electrolyte to escape through the screw thread. The electrode is now ready for calibration and use. See the instruction manual for more detailed directions.

If the electrode is not to be used for 24 hours, store with membrane in the calibration sleeve to prevent the electrolyte from drying out.

MEASUREMENT OF OXYGEN

1. Select the desired mode (e.g., mg/L) and immerse the probe in the flow-through cell. The most accurate values for DO are obtained when the inlet of the flow-through cell is focused directly onto the oxygen electrode.
2. Attach the pump outflow to the base of the flow-through cell, and bleed off any headspace from the cell as the water is flowing through the cell.
3. Read DO when the reading has stabilized and after the cell has been flushed with approximately 2 volumes of water.

**STANDARD OPERATING PROCEDURE FOR DETERMINATION OF PERCENT
MOISTURE IN SOLIDS****SOP-5**

Moisture content of solids is determined from the mass lost on drying.

1. Weigh a clean, dry weighing dish or use disposable weighing tins.
2. Weigh sample plus dish to the nearest 0.1 g. Record the weight.
3. Place 40-50 g field-moist sample in dish.
4. Place the dish plus sample in a drying oven set at 103–105 °C.
5. Dry the sample for at least 2 hours, cool to room temperature in a desiccator, and reweigh. Record the weight.
6. Place sample in oven for a minimum of 30 minutes.
7. Cool the sample to room temperature in a desiccator and reweigh. Record the weight.
8. Constant weight has been achieved if the weights recorded in Steps 5 and 7 agree to within ± 0.5 mg.
9. If constant weight has not been achieved, repeat Steps 5 and 6 until successive weights agree to within ± 0.5 mg.

CALCULATIONS

1. Percent moisture = $\frac{\text{weight of wet sample} - \text{weight of dry sample}}{\text{weight of wet sample}} \times 100$
2. Report calculated result to 0.01 percent.